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A POWER CABLE COMPRISING AT LEAST ONE NANOCOMPOSITE COMPONENT COVERING LAYER

Ins A1 >

The invention relates to a power cable having significantly improved mechanical, thermal, electrical or fire-resistance characteristics compared to the cables currently known in the art. The expression "power cable" refers to any electrical conductor intended to transport electrical energy and comprising at least one covering layer or sheath.

The invention relates more particularly to the material included in at least one of the covering layers placed around said electrical conductor.

Cablemakers are constantly concerned to improve the above characteristics of onboard cables and also to reduce their weight.

In addition to seeking to improve the characteristics of the materials used, cablemakers are on the lookout for solutions that can easily be integrated into existing production lines, such as production lines for fabricating cables by extruding molten polymers around the conductive core or for fabricating insulated wires by cross-linking a polymer in the liquid state or in solution.

The function of the covering is to protect the conductive core from external mechanical attack and ingress of moisture and to provide electrical insulation, if necessary. It must also provide sufficient fire resistance. At present most coverings include a continuous matrix, usually of polymer, and possibly containing particles of a charge, which may be an inorganic charge, such as the polymer/montmorillonite mixture for electrical cables described in Patent Application GB-A-2 113 453.

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The object of the present invention is to propose a power cable in which the above characteristics are significantly improved by the presence of at least one covering layer into which a nanocomposite component that

can be used in existing industrial fabrication processes is introduced or polymerized in situ. A nanocomposite component of this kind is described in Patent Application WO-A-93/94 117, for example.

The invention provides a power cable comprising a conductive material core surrounded by at least one covering layer, the cable being characterized in that said layer is constituted essentially of a material comprising an inorganic compound of sheet structure and an organic compound inserted between the layers of said inorganic compound.

At present inorganic charges are frequently used in one cable covering layer or another, but the particle size of such charges is of the order of one micrometer (micron) and the charges are dispersed in a polymer and retain their original size after mixing with the polymer.

The present invention uses an inorganic compound of sheet structure such that an organic compound can be inserted between its layers after special treatment. The original particle size of the inorganic compound is of the order of one micron. When an organic compound is inserted between the layers, the inorganic compound is exfoliated to form a composite material. After insertion of the organic compound and exfoliation of the inorganic compound, the inorganic compound is distributed homogeneously within the composite material and has a particle size of the order of one nanometer. This significantly improves the existing properties of the material and introduces specific new properties. Said material is usually referred to as a nanocomposite material or component.

The expression "essentially constituted of" means that the layer can further include relatively smaller quantities of additives intended in particular to facilitate shaping it (plasticizers, lubricants, etc.), to retard aging (stabilizers, U.V. absorbers, flame retardants, anti-oxidizing agents, anti-impact agents,

etc.), or to modify its appearance (colored pigments, etc.).

The inorganic compound can be chosen from graphite or an inorganic oxide. Graphite is chosen if a conductive layer is required and an inorganic oxide is chosen if an electrically insulative layer is required. In this instance an oxide is preferably chosen. The inorganic oxide can be chosen from, for example, a silicate such as asbestos (hydrated silicate), feldspar (double silicate of aluminum and an alkaline or alkali-earth metal), a silicate of magnesium such as talc or steatite, or serpentine (magnesium silicate), a silico-aluminate such as mica (biotite, muscovite, phlogopite) or clay, alumina, titanate or zirconia, provided that it has a sheet structure.

The inorganic oxide is preferably a silicate and more preferably an aluminosilicate such as natural or artificial clay, possibly bridged. The clay preferably has a crystalline structure formed of stacked layers and preferably has OH- ions on the surface. The clay can be chosen from kaolin (dihydrated aluminum silicate), smectite, montmorillonite, bentonite, beidellite, nontronite, saponite, hectorite, vermiculite, wollastonite or a mixture of several clays.

In a preferred embodiment of the present invention, the clay chosen is montmorillonite, which is also known as "Fuller's earth" when it contains calcium or as bentonite when it contains sodium.

The organic compound inserted between the layers of the inorganic compound is preferably a polymer, an oligomer or a monomer that is polymerized in situ.

In a process of fabricating cables by extrusion, an extrudable polymer is used that can be chosen from a polyolefin such as polyethylene (PE) or polypropylene (PP), polybutylene terephthalate (PBTP), a vinyl polymer such as polyvinyl chloride (PVC), an elastomer (either halogenated or not), or a thermoplastics material,

silicone, copolymers thereof such as copolymers of ethylene, and a mixture of the above. Ethylene copolymers can be chosen from a copolymer of ethylene and vinyl acetate (EVA), a copolymer of ethylene and propylene (EPR), a copolymer of ethylene and an alkyl acrylate, such as the copolymer of ethylene and ethyl acrylate (EEA) or methyl acrylate (EMA), a copolymer of ethylene and acrylic acid, a terpolymer of ethylene, or the same polymers including specific functional groups (acids, epoxy, etc.).

In a process of fabricating cables using polymers in the liquid state, the polymer used is chosen from epoxy resin, polyester, a polyimide such as polyetherimide or polyamidimide, polyamide (PA), polyurethane, silicone, or a copolymer or mixture of the polymers previously cited.

The covering layer can be constituted exclusively of an insulative material.

The covering layer can be constituted of a layer of insulative material surrounded by an external protective covering layer.

The insulative material can be at least partly constituted of said nanocomposite material comprising an inorganic compound of sheet structure and an organic compound inserted between the layers of said inorganic compound.

The external covering layer can be at least partly constituted of said nanocomposite material comprising an inorganic compound of sheet structure and an organic compound inserted between the layers of said inorganic compound.

The cable can be a medium-voltage to high-voltage DC power cable, the covering layer comprising at least one semiconductor screen. The semiconductor screen can be essentially constituted of said nanocomposite material comprising an inorganic compound of sheet structure and an organic compound inserted between the layers of said inorganic compound.

The invention also provides a method of fabricating a cable as described above, including the following steps:

- treating the inorganic compound with an agent to render it compatible with the organic compound,
- mixing the treated inorganic compound with the organic compound at a temperature higher than the temperature at which the organic compound softens or melts, and
- obtaining the material with the organic compound inserted between the layers of the inorganic compound.

The inorganic compound is treated with a surfactant compatible with the organic compound to encourage insertion of the organic compound between the layers of the inorganic compound.

In one embodiment of the present invention, the inorganic compound is clay and the compatibilizing agent is chosen from a quaternary ammonium salt, an oxide of polyethylene and a phosphorus-containing derivative.

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Other advantages and features of the present invention will emerge from the following description, which is given with reference to the accompanying drawing, in which:

Figure 1 is a diagrammatic representation in cross-section of an embodiment of a power cable of the present invention.

Figure 2 is a diagrammatic representation in cross-section of another embodiment of a power cable of the present invention.

Figure 3 is a diagrammatic representation in cross-section of a further embodiment of a power cable of the present invention.

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The invention relates to a power cable 1 comprising a conductive material core 2 surrounded by a sheath 3 constituted of a covering layer 4.

According to the invention, the layer 4 is essentially constituted of a nanocomposite material

comprising an inorganic compound of sheet structure and an organic compound inserted between the layers of said inorganic compound.

Said inorganic compound can be graphite, for example, if a nanocomposite material having semiconductive properties is required.

In the embodiment shown in Figure 1, the resulting power cable 1, which is an insulated electrical wire, has significantly improved fire, water, and solvent resistance.

In the embodiment shown in Figure 2, the sheath 3 is constituted of an external protection covering 5 in addition to the insulative material layer 4. The insulative material layer 4 or the external covering 5 can be at least essentially constituted of said nanocomposite material.

The Figure 2 embodiment is typical of low-voltage AC cables. Integrating the nanocomposite material into the insulative material layer 4 and/or the external covering 5 significantly improves its mechanical, fire resistant, and flame retardant properties, and also its impermeability to water and to solvents.

In the embodiment shown in Figure 3, the power cable is a medium-voltage to high-voltage DC cable and the sheath 3 comprises at least one semiconductive screen 6a, 6b in addition to the insulative material layer 4 and the external protection covering 5. The semiconductive screen can be essentially constituted of said nanocomposite material.

The mechanism of forming the nanocomposite material and extruding it encourages an orientation of the organic compound, for example the polymer, which limits the migration of space charges.

Introducing a nanocomposite material into the insulative material layer 4 of a medium-voltage or high-voltage DC cable therefore improves the resistance of the cable to breakdown in the event of a change of polarity.

The mechanism of forming the nanocomposite material reduces the percolation threshold of the mixture, which significantly reduces the concentration of the organic compound in the inorganic compound. Using an internal semiconductive screen 6a constituted essentially of a nanocomposite material, for example a material based on graphite, therefore significantly improves the interface between the conductive core and the insulative layer.

Finally, introducing a nanocomposite material, for example a material based on a silicate or silicated clay, into the external semiconductor screen 6b and/or the external sheath 4 significantly improves its fire-resistance and flame propagation characteristics, and also its impermeability to water and to solvents.

Of course, the present invention is not limited to the embodiments described and shown, and is open to many variants that may suggest themselves to the skilled person and that are within the scope of the invention. In particular, the structure of the cables can be that of any power cable known in the art, and likewise inclusion of a nanocomposite material can be envisaged in any cable including an insulation, a semiconductive screen or a protective sheath.